Effect of Designed Bundle Protocol about Ventilator Associated Pneumonia on Nurses' Performance, Compliance, and Patient Outcomes

Sohier M. Weheida[1], Eman S. Omran[2], Amal S. Taha[3]

[1]Medical Surgical Nursing Department, Faculty of Nursing, Alexandria University, Alexandria, Egypt.
e-mail: Wehedasohier@gmail.com
[2]Medical Surgical Nursing Department, Faculty of Nursing, Benha University, Benha, Egypt.
e-mail: aymanmran58@gmail.com
[3]Medical Surgical Nursing Department, Faculty of Nursing, Benha University, Benha, Egypt.
e-mail: Amal.said22@yahoo.com

Received April 1, 2022, accepted May 15, 2022, Published July 1, 2022.

ABSTRACT

Context: Ventilator-associated pneumonia (VAP) is considered one of the leading causes of morbidity and mortality due to nosocomial infections among ventilated patients.
Aim: To evaluate the effect of a designed bundle protocol about ventilator-associated pneumonia on nurses' performance, compliance, and patient outcomes.
Methods: The study employed the quasi-experimental research (pre/post-test) (study/control) design. This study was conducted at the intensive care unit of Benha University Hospital. A convenience sample of 50 critical care nurses and a purposive sample of 66 patients were enrolled in the current study. Three tools were used to collect data. Nurses' knowledge assessment questionnaire; nurses' practice assessment checklist; The VAP bundle compliance checklist; and patient outcomes assessment record.
Results: Statistically significant improvement in total knowledge and practice mean scores post implementing a designed bundle protocol compared to pre-implementing a designed bundle protocol at p <0.001. Also, there was a statistically significant improvement in nurses' compliance with a highly statistically significant difference between nurses' compliance with practices of VAP bundle pre-and post designed bundle protocol implementation. Immediately after a designed bundle protocol implementation, the study group patients exhibited a statistically significant difference between all clinical pulmonary infection scores items except for oxygenation status and radiographic findings.
Conclusion: The study group nurses who received designed bundle protocol training would get improved knowledge, practices, and compliance scores than pre-designed bundle protocol training. Also, the study group of patients who were cared for by trained nurses on the designed bundle protocol would get better outcomes such as a better score of CPIS, shorter length of stay in the intensive care unit, less duration on mechanical ventilation compared to the control group who received routine hospital nursing care. The study recommended replication of the study using a large probability sample from a different geographical area to allow for greater generalization of the results.

Keywords: Bundle, compliance, nurses' performance, outcomes, ventilator-associated pneumonia

Citation: *Weheida, S. M., Omran, E. S., & Taha, A. S. (2022).* Effect of designed bundle protocol about ventilator-associated pneumonia on nurses' performance, compliance, and patient outcomes. *Evidence-Based Nursing Research*, 4*(3)*, 71-85. http://doi.org/ 10.47104/ebnrojs3.v4i3.251.

1. Introduction

Ventilator-associated pneumonia (VAP) is a nosocomial pulmonary infection in patients connected to mechanical ventilation. In developing nations, VAP is a significant global health problem, and a prevalent healthcare-associated illness (HAI) linked to patient cost burden, prolonged hospital stays, and mortality *(Ghimire & Neupane, 2018)*. The term "VAP" refers to an infection of the pulmonary parenchyma that appears after 48 hours of mechanical ventilation intubation or within 48 hours following ventilator disconnection. *(Schauwvlieghe et al., 2018).*

The incidence of VAP varies based on the case mix and the diagnostic criteria utilized. Immunocompromised, surgical, and elderly patients have the highest rates *(Torres et al., 2017).* The worldwide incidence of VAP is about 10–28%, whereas, in developing nations, it varies from 10 to 41.7 cases per 1000 ventilator days *(Kalil et al., 2016).* The length of stay in the critical care unit is extended by 5 to 7 days, and the death rate attributed to VAP is 27%. In developed nations, the cost of VAP is projected to be an additional $40,000 per hospital admission for each patient with the disease and to total $1.2 billion annually *(Bakhtiari et al., 2018).* Additionally, VAP is linked to a longer hospital, intensive care unit (ICU) stay, higher mortality and morbidity rates, and more extensive use of healthcare resources *(Rakhi & Navita, 2020).*

Ventilation-related factors (such as the use of an endotracheal tube to access the airway and subsequent micro aspirations) and patient-related factors (for example, pre-existing pulmonary disease) are two categories of risk factors for VAP *(Klompas, 2017).* Nurses can avoid VAP

[1]Correspondence author: Eman Sobhy Omran

and enhance patient outcomes if they are knowledgeable. A defining characteristic of professional nursing practice is the application of knowledge to the care of critically ill patients. The bedside critical care nurse is directly responsible for many non-pharmacological techniques to avoid VAP, which can be easily implemented at the lowest cost. Neglecting any of these could put the patient at risk of complications *(Boltery et al., 2017).*

The concept of the care "bundle" works to help apply evidence-based care and best practices. A bundle is ‘‘a systematized way of humanizing the processes of care and improving patient outcomes that, when performed collectively and reliably, have proven to improve patient outcomes by assisting, promoting changes in patient care and supporting guideline compliance *(Rodrigues et al., 2016).* The ventilator bundle consists of the following items: elevating the head of the bed to 30 to 45 degrees; daily "sedation vacation" to determine readiness for extubation; prophylaxis for peptic ulcer disease, such as checking the gastric residual volume every 4 to 6 hours; routine acidification of gastric feeding; and deep venous thrombosis prophylaxis such as the use of mechanical devices *(Institute for Healthcare Improvement, 2020).*

Most healthcare professionals are nurses, referred to as the "center of the health care system ." Their adherence to the bundle protocol appears to be more important in preventing disease complications since they spend more time with patients than other healthcare professionals *(Abdelazeem et al., 2019).* The study by *Osti et al. (2017)* documented that implementing a ventilator bundle was linked to a significant decrease in hospital costs, intensive care unit length of stay, antibiotic administration, and rates of VAP. In conclusion, using a ventilator bundle appears to be a successful strategy for improving patient outcomes.

2. Significance of the study

Ventilator-associated pneumonia has been linked to high morbidity and mortality rates, longer stays in intensive care units, and higher hospital expenses. In developing nations, the studies claimed to have greater VAP rates than in developed nations *(Khalil et al., 2021).* In Egypt, a surveillance program for hospital-acquired infection (HAI) and antimicrobial resistance (AMR) was conducted in collaboration with the United States Agency for International Development (USAID) from June 2011 until January 2012. Forty-three intensive care units (ICUs) from both the Ministry of Health and University Hospitals are included in the surveillance project's investigation of HAI and AMR in 11 hospitals in Egypt. As a result, pneumonia accounted for 50% of the HAIs. 15% of urinary tract infections and 20% of bloodstream infections. Device-associated infections comprised a sizable part of all infections (64%), whereas VAP accounted for 92% of the overall hospital-acquired pneumonia *(USAID Assist Project, 2018).*

The intensive care unit at Benha University Hospital documented an admission number of ventilator-associated pneumonia by case definition as 82 patients in 2018 and 2019 *(Benha University Office Census, 2019).*

From the researchers' experience in ICU, they observed unsatisfactory nurses' knowledge and inadequate practices regarding implementing care bundle procedures for mechanically ventilated patients, which elevates the VAP rate. Consequently, the purpose of this study is to evaluate the impact of ventilator-associated pneumonia tailored bundle protocol on nurses' performance, compliance, and patient outcomes.

3. Aim of the study

This study aimed to evaluate the effect of the designed bundle protocol about ventilator-associated pneumonia on nurses' performance, compliance, and patient outcomes.

Operational Definitions

Nurses' performance: is the studied nurses' knowledge and practice.

Compliance is defined in this study as the commitment of nurses to the VAP bundle components.

A designed care bundle protocol: is a set of straightforward practices such as following preventive precaution measures, care of mechanical ventilator, suctioning and airway care, enteral feeding and care, oral hygiene, patient positioning, chest physiotherapy, and closed suction system.

Patient Outcomes: The patient outcome in this study means clinical pulmonary infection score to monitor a decrease in the frequency of VAP after ventilator bundle protocol implementation, patient length of ICU stay, and duration of mechanical ventilation.

Research Hypothesis

The following research hypotheses were formulated to fulfill the aim of this study:

H1: Nurses exposed to the designed bundle protocol will exhibit higher knowledge scores after bundle implementation than before implementation.

H2: Nurses exposed to the designed bundle protocol will exhibit higher practice scores after bundle implementation than before implementation.

H3: Nurses exposed to designed bundle protocol exhibit higher compliance scores after bundle implementation than before implementation.

H4: Patients cared for by a designed care bundle protocol will exhibit a decrease in clinical pulmonary infection score, length of stay in ICU, and duration on mechanical ventilator compared to controls.

4. Subjects & Methods

4.1. Research design

A quasi-experimental research design was used to compare the nurses' performance and compliance before and after bundle implementation. The study/control design was used to compare the patient outcomes in the study and control groups). Establishing a cause-and-effect link between an independent and dependent variable is the goal of a quasi-experimental design. A quasi-experiment, however, does not rely on random assignment, unlike an actual experiment. Instead, non-random criteria are used to classify participants. A quasi-experimental design is helpful when real trials cannot be used for moral or practical reasons. *(Reichardt, 2019).*

Variables: The independent variable is the designed care bundle protocol, while the dependent variables are nurses' knowledge, practices, compliance, and patient clinical outcomes regarding ventilator-associated pneumonia.

4.2. Research Setting

The study was conducted at the intensive care unit of Benha University Hospital. It consists of 22 beds and is located on the second floor.

4.3. Subjects

A convenience sample of all available nurses (50) working in the intensive care unit agreed to participate in the study regardless of their demographic characteristics (Group A).

A purposive sample of 66 adult patients was recruited in this study according to inclusion and exclusion criteria and divided randomly into two equal groups: The pre-designed bundle protocol implementation group (control group=33) and the post-designed bundle protocol implementation group (study group=33) (Group B).

Both the study and control groups received standard hospital care. Nurses treated the control group before being exposed to a planned bundle regimen, which was the difference. However, nurses participating in a planned bundle protocol implementation provided care following the bundle protocol to study group patients. Both studied groups were selected according to the following inclusion and exclusion criteria.

Inclusion criteria:
- Patients of both gender and their age between (20-65).
- Patients on mechanical ventilation.
- A score of less than six on the clinical pulmonary infection scale.

Exclusion criteria
- Patients with brain stem infarction as evidenced from the patient file.
- Patients with major cardiothoracic or abdominal surgery.
- Patients with multiple organ dysfunction syndromes
- Patients with neuromuscular diseases.

The sample size was estimated based on the previous year's census report of the intensive care unit's admission to Benha University Hospital *(Benha University Office Census, 2019)*, utilizing the following equation *(Krishnappa et al., 2018).*

$$n = \frac{N}{1+N(e)2}$$

Description:
n= sample size (66)
N= total population (82)
e= margin error (0.05)

4.4. Tools of data collection

The following tools were utilized to collect pertinent data.

4.4.1. Nurses' Knowledge Assessment Questionnaire

The researchers developed the questionnaire in simple Arabic language based on reviewing relevant recent literature *Ahmed (2019); leone et al. (2018); Busi and Ramanjamma (2016)*. It was used to assess nurses' knowledge regarding the prevention of ventilator-associated pneumonia and included three parts:

Part 1 concerns the nurses' demographic characteristics regarding their age, educational level, job, marital status, years of experience, and attending training courses related to preventing ventilator-associated pneumonia.

Part 2 is concerned with nurses' knowledge assessment. It was utilized to test the theoretical background of nurses related to all aspects of the designed care bundle protocol for preventing ventilator-associated pneumonia. It included 45 closed-end MCQ questions. It consists of four categories, including information related to anatomy and physiology of the respiratory system (5 questions), ventilator-associated pneumonia (definition, causes, signs, and symptoms, complications, nursing role, and outcomes) (10 questions), nursing management of patients on mechanical ventilation (10 questions), components of bundle related to prevention of ventilator-associated pneumonia (precaution measures, care of mechanical ventilator, enteral feeding and care, patient positioning, suctioning and airway care, chest physiotherapy (20 questions). This tool was used during the pre and post-intervention.

Scoring system

Each correct answer was given one mark, and the incorrect answer was given zero. The total score of knowledge was 45 marks equal (100%). The total score was then converted into percentage as follows:
- Less than 60% (less than 27 scores) was considered a poor level of knowledge.
- 60% to 75% (27 to 34 score) was considered the average level of knowledge.
- 75% (35 scores or above) are considered a good level of knowledge.

4.4.2. Nurses' Practice Observational Checklist

Nurses' practice observational checklist was utilized to assess the nurses' practices regarding preventing ventilator-associated pneumonia before and after implementing a designed care bundle protocol. The researchers developed it utilizing relevant recent literature *Ab Manap (2019); Aloush (2018).* It included nine categories of care which covered the actual nurses' practices of hand hygiene (12 steps), wearing protective clothes (Masks, gloves, and gowns) (12 steps), care of mechanical ventilator, and adjusting settings (30 steps), endotracheal tube (care, suctioning techniques, and extubation) (70 steps), enteral feeding, removal, and care (38 steps), oral hygiene (13 steps), patients' positioning (10 steps), chest physiotherapy (percussion, vibration, and postural drainage) (50 steps), closed suctioning system (15 steps).

Scoring system

Three levels of scoring for practice were used: completely done was scored (2), incompletely/incorrectly done was scored (1), and the steps that were not done were scored (0). The total scores for all procedural steps were 500 (100%). The total score was then converted into percentage as follows:

- Less than 60% (299 scores) is considered poor practice.
- 60% to 75% (300 to 375 score) are considered average practice.
- >75 % (376 scores and above) is considered good practice.

4.4.3. Nurses' Compliance Checklist for VAP Bundle

It was developed by the researcher from *Ali (2013); Osti et al. (2017).* It evaluated critical care nurses' compliance regarding a designed care bundle protocol for preventing ventilator-associated pneumonia. It covered eight main domains involving infection control practices (5 practices), positioning strategies (1 practice), deep vein thrombosis (DVT) prophylaxis such as the use of mechanical devices (socks and compression pump) for prevention of DVT (1 practice), ventilator circuit care such as the use of disposable ventilator circuit for each patient, timely emptying of the water container of the ventilator circuit, replacement of the humidification system in case of evident contamination (5 practices), endotracheal suctioning and care (10 practices), oral care (2 practices), peptic ulcer prophylaxis such as checking the gastric residual volume every 4 to 6 hours; administer intermittent rather than continuous enteral feeding and performing routine acidification of gastric feeding (3 practices); and weaning trials by daily examination of the patient's readiness for separation from mechanical ventilation and (2 practices). Each area had sub-items detailing the care bundle protocol.

Scoring system

The score of each item was calculated as compliant (2), partially compliant (1), and non-compliant (0). The total maximum score equals 58 marks. The total score was then converted into percentage as follows:

- Less than 60% (34 marks) is considered non-compliant.
- 60% to 75% (35 to 43 marks) are partially compliant.
- 75% (44 marks and above) is considered compliant.

4.4.4. Patient' Outcomes Record

The researchers developed it after reviewing the relevant literature *Boltery et al. (2017); Kao et al. (2019); Khalil et al. (2021); Mishra and Rani (2020); Osti et al. (2017).* It was used to measure patients' outcomes before and after implementing a designed bundle protocol the patients' demographic characteristics such as age, gender, marital status, occupation, and residence, in addition to patients' medical data such as diagnosis, smoking history, and the causative organism. Besides, the length of patient stay in the intensive care unit and duration of a patient on ventilation were recorded for each patient. They were counted in days.

4.4.4.1. Clinical Pulmonary Infection Score (CPIS)

It was adopted by *Zilberberg and Shorr (2010).* It evaluated six variables, including vital signs (temperature), white blood cell count, tracheal secretions, oxygen saturation, chest radiographic findings, and culture result of pathogenic bacteria. It was used for measuring the frequency of ventilator-associated pneumonia.

Scoring system:

Each of the six-sub items was scored from zero to two. They were evaluated as follows: normal (0), moderate (1), and severe (2), with a total score of (12). The total score was categorized as follows; a score ≥6 suggests pneumonia. If <6, they probably do not have pneumonia.

4.5. Procedures

A group of five experts (one professor of critical care nursing, one professor of critical care medicine, and three professors of medical surgical nursing) revised the data collection instruments for thoroughness, applicability, and legibility to ascertain the content and face validity. The same experts verify the contents of a designed bundle protocol. The modification was made following the panel's assessment of the content's appropriateness, completeness, and sentence clarity, as well as the suitability and correctness of the bundle protocol.

Cranach's Alpha coefficient test was used to test the tools' reliability and that each tool consisted of relatively homogenous items. It was 0.92 for the nurses' knowledge assessment questionnaire and 0.955 for the nurses' practice observational checklist. Nurses' compliance checklist for VAP bundle reliability was 0.866. The reliability of the clinical pulmonary infection score was 0.888.

Ten percent of the total study individuals participated in the pilot study (six nurses and five patients). The pilot study was done to assess the amount of time needed for data collection and to test the tools' clarity, applicability, practicality, and relevance. Based on the findings of the pilot testing, modifications were made to all tools. As a result, the pilot study sample was left out of the final sample.

Field of work：The data collection was completed in 12 months, from August 2019 to August 2020. The study was conducted through four phases (preparatory and Assessment, planning, implementation, and evaluation).

During the assessment phase, the literature and studies linked to the research problem and theoretical knowledge were reviewed using textbooks, evidence-based research with supporting data, international guidelines, online periodicals, and journals.

For Nurses: The researchers visited the intensive care unit three days weekly (morning and afternoon) to collect the data using previous tools. The researchers interviewed the available nurses, an average of three to four nurses were interviewed per/day. This interview took about 20-30 minutes. At the beginning of the interview, the researchers greeted nurses in the intensive care unit, explained the character, aims, and expected outcomes of the study, and took their verbal approval to participate in the study before data collection; then, the researcher assessed the nurses' knowledge and practice level regarding caring for mechanically ventilated patients by using nurses' knowledge assessment questionnaire and nurses' practice observational checklist. The researchers assessed compliance levels through observing the nurses regarding the eight main nursing practices in the designed bundle (before bundle implementation). This period is called (Pre-test) before implementing a designed bundle protocol which takes one month.

For patients: The researchers assessed all ventilated patients to assess the patients who met the inclusion criteria of this study. Sixty-six mechanically ventilated patients fulfilling the inclusion criteria were selected. They were classified into two groups according to the phase of a designed protocol implementation. Group I (pre-intervention group) consisted of 33 patients who received routine care from the nurses before a designed bundle protocol implementation. Group II (post-intervention group) consists of 33 other patients fulfilling the same inclusion and exclusion criteria, receiving care from nurses after training on the bundle protocol implementation.

The researcher used the patient record at the time of patient admission to collect the baseline data within the first 24 hours of intubation and continued daily for ten days of ICU stay. In addition, the researchers measured the frequency of pneumonia using a clinical pulmonary infection score for each patient on a ventilator for more than 48 hours to exclude the patients who had an infection at the time of admission through estimation of the clinical pulmonary infection score as follows: At the first 24-48 hour of patients' intubation, throat swap and endotracheal aspirate specimen for gram stain and culture was firstly obtained and send to the laboratory as routine patient investigations within intensive care unit. A chest X-ray accompanied this investigation.

The score was calculated based on the first six clinical variables (temperature, white blood cells, secretion, oxygenation status, radiographic findings, and culture of pathogenic bacteria). This score revealed the probability of the infection being either present or absent. If it is less than six, those were included in the sample. If this score was more than six, it was considered a high probability of pneumonia, and those patients were treated as if they had pneumonia and excluded from the study sample. The record is also used to register the occurrence of ventilator-associated pneumonia, length of ICU stays, and duration on a mechanical ventilator. This phase took three months.

Planning phase (Bundle protocol development): A designed bundle was developed by researchers based on nurses' and patients' needs assessment, literature review, and international guidelines *Centers for Disease Control and Prevention (CDC) (2021); European Society of Intensive Care Medicine (2017); Boltery et al. (2017); Kao et al. (2019); Khalil et al. (2021),* researchers' experience, and experts' opinions. The researchers designed a nurses' guidelines booklet including all bundle protocols in the Arabic language with illustrations involving theoretical background about the VAP and bundle protocol practices.

The theoretical background included general knowledge regarding anatomy and physiology of the respiratory system, ventilator-associated pneumonia as definition, risk factors, causes, signs and symptoms, nursing management of ventilator-associated pneumonia, plus components of designed bundle protocol such as positioning, infection control measures, peptic ulcer prophylaxis, weaning trials, deep venous thrombosis prophylaxis.

Bundle protocol practices included hand hygiene, wearing protective clothes (gloves, gowns, and mask), care of mechanical ventilator patient and ventilator settings, endotracheal intubation tube care (suctioning techniques and extubation), enteral feeding and removal, oral hygiene, patients' positioning, chest physiotherapy (percussion, vibration, and postural drainage), and closed suctioning system.

The implementation phase was achieved through training sessions over three weeks for each sub-group of nurses. This phase took six months. Each session started with a summary of the previous session and the objectives of the new one. Motivation and reinforcement during the session were used to enhance motivation for participation in this study. Grouping the nurses, ten nurses in each group according to their shifts' distribution. Sessions were given to 5 groups (10) of nurses, each divided into "subgroups" five nurses in each group.

The total numbers of sessions were seven. It is divided into three sessions for knowledge and four sessions for practice. The knowledge sessions ranged from 30 to 55 minutes according to the unit's workload, the number of patients assigned to each nurse, and the patient's critical condition. Each nurse has supplemented with a guidelines booklet. The researchers continued to reinforce the gained information, answered any raised questions, and gave feedback. The practical sessions ranged from 45-60 minutes, and the number of sessions was four for each group (5 nurses). Teaching methods were lecture, group discussion, demonstration, and re-demonstration. The media utilized were handouts, PowerPoint presentations, videos, and poster presentations for ventilator-associated pneumonia protocols.

Evaluation phase:

For nurses, the researchers evaluated the effect of implementing the designed bundle protocol by comparing the nurse's knowledge and practice level before and after a designed bundle protocol using the same format of the study tools pre and immediately post a designed bundle protocol implementation. Observed nurses' compliance to the designed bundle protocol was assessed two times pre and immediately after a designed bundle protocol implementation. This phase took two months.

For patients, the researcher met the control group of patients (pre-designed bundle protocol implementation) who received routine hospital care to complete the sociodemographic and medical history sheet as well as to detect the frequency of ventilator-associated pneumonia (The clinical pulmonary infection score). Moreover, evaluate the length of ICU stay and patient stay on the ventilator.

As well, the researchers met the study group patients after designed bundle protocol implementation who received care from nurses trained in implementing a designed bundle protocol to complete the sociodemographic and medical history sheet as well as to detect the frequency of ventilator-associated pneumonia (The clinical pulmonary infection score). Furthermore, evaluate the length of ICU stay and patient stay on the ventilator. This phase took three months.

4.6. Data analysis

The collected data were organized, coded, computerized, tabulated, and analyzed using the Statistical Package for Social Science (SPSS) version (25). Data analysis was accomplished using the number, percentage distribution, chi-square test, mean, standard deviation, and correlation coefficient; a paired t-test was used to test the significance of some variables. Statistical significance was considered as
follows:
- P-value >0.05 Not significant
- P-value ≤0. 05 Significant
- P-value ≤0.001 Highly significant

5. Results

It is clear from table 1 that 70% of nurses were less than 30 years old, with a mean age of 30.82±8.88. Regarding educational level, 46% had a secondary school Diploma in nursing. Also, 76% were working as staff nurses. Concerning marital status, 88% were married. Regarding years of experience, 56% had 5-10 years of experience, while 92% did not receive any previous training on the prevention of ventilator-associated pneumonia.

Table 2 represents the comparison of the studied nurses' knowledge mean score before and after bundle implementation. The table reveals a statistically significant improvement in all knowledge elements at p <0.001 and for the total knowledge mean score after bundle implementation compared to the mean score before the implementation.

Table 3 documents the comparison of nurses' total knowledge pre- and post-implementation of the bundle protocol that 74% of the nurses had poor knowledge levels pre-designed bundle protocol implementation. However, immediately after the designed bundle protocol implementation, 60% of nurses got a good knowledge level. Statistically significant differences were found at p <0.001 between pre- and post-designed bundle protocol implementation.

Table 4 compares the studied nurses' practice mean scores before and after bundle implementation. The table reveals a statistically significant improvement in all practices at p <0.001 and for the total practice mean score after bundle implementation compared to the mean score before the implementation.

Table 5 documents that 70% of the nurses had poor practice level pre-designed bundle protocol implementation. However, 66 % got a good practice level immediately after implementing the bundle protocol. A statistically significant differences were found at p <0.001 between pre- and post-designed bundle protocol implementation.

Table 6 compares the studied nurses' compliance with bundle practices before and after implementation. The table reveals a significant improvement in mean compliance with all practices at p <0.001 and the total practice compliance mean score after bundle implementation compared to the mean score before the implementation.

Table 7 illustrates that 64% were non-compliant to bundle practices pre-designed bundle protocol implementation. However, more than half of nurses (58%) got good compliance immediately after the implementation of bundle protocol. There is a statistically significant difference between nurses' total compliance levels in pre/post-designed bundle protocol implementation p ≤0.001.

Table 8 demonstrates no statistically significant correlation between total compliance, nurses' knowledge, and practice score pre-designed bundle protocol implementation. In comparison, there is a statistically significant positive correlation between compliance, total nurses' knowledge, and practice score post-designed bundle protocol implementation (p <0.001).

It is clear from table 9 that patients' age was more than 40 years old among 75.8%; 72.7% of the control and study groups, respectively. More than half (51.5%; 54.5%, respectively) of control and study patients were females. Concerning marital status, most control and study patients were married (87.9%; 90.9%), working 63.6% & 57.6%, and the highest percentage of both groups were from rural areas (66.7% &60.6%). Regarding medical history, the highest percentage of the control and study group had a medical history of cerebrovascular stroke (30.3%; 36.4%), diabetes (45.45%; 30.3%), cerebral hemorrhage (21.2%; 18.2%), and without a history of smoking among 75.75% & 81.8% of control and study group respectively. The most common causative organism in the control and study groups is Staphylococcus aureus (54.5% & 60.6 %, respectively).

No statistically significant differences were seen between the two groups concerning the demographic and medical variables mentioned above, which indicates that the two groups were nearly homogenous.

Table 10 shows a statistically significant difference between the control and study group patients related to all items of clinical pulmonary infection score such as temperature, white blood cells count, secretion, and culture of pathogenic bacteria when comparing pre- and post-implementation of bundle protocol with respectively at p ≤0.05. Except related to oxygenation status and radiographic findings respectively with p >0.05.

Table 11 shows a statistically significant difference between total clinical pulmonary infection mean score before and after implementation of the bundle protocol with a p <0.001.

Table 12 shows a statistically significant difference between control and study group patients related to the length of stay within the intensive care unit and duration of the patient on a mechanical ventilator at p ≤0.001.

Table (1): Frequency and percentage distribution of the studied nurses' demographic characteristics (n=50).

Demographic data	No	%
Age (years)		
<30	35	70
30 and more	15	30
Mean±SD	30.82±8.88	
Educational level		
Secondary school nursing	23	46
Technical institute of nursing	15	30
Baccalaureate degree of nursing	12	24
Job		
Staff nurse	38	76
Head nurse	12	24
Marital status		
Married	44	88
Unmarried	6	12
Years of experience		
<5 years	12	24
5-10 years	28	56
>10 years	10	20
Mean±SD	9.58±9.44	
Attendance of previous training courses on the prevention of ventilator-associated pneumonia		
Yes	4	8
No	46	92

Table (2): Comparison of the nurses' knowledge before and after implementing the bundle protocol training (n=50).

Knowledge elemets	No of items	Pre (n=50) Mean±SD	Post (n=50) Mean±SD	t-Test	P-Value
Anatomy and physiology of the respiratory system	5	1.24±0.61	2.96±1.24	8.73	<0.001
Ventilator-associated pneumonia	10	7.04±0.93	8.84±0.98	9.35	<0.001
Nursing management of patients on mechanical ventilation	10	7.14±0.89	8.84±1.00	8.92	<0.001
Components of bundle protocol for ventilator-associated pneumonia	20	10±3.54	15.38±3.73	7.38	<0.001
Total knowledge	45	25.42±5.70	36.08±6.67	8.58	<0.001

Table (3): Comparison of the nurses' total knowledge pre- and post-implementation of the bundle protocol (n=50).

Knowledge level	Pre (n=50)		Post (n=50)		X^2	P-value
	N	%	N	%		
Poor	37	74	9	18		
Average	8	16	11	22	35.3743	<0.001
Good	5	10	30	60		

Table (4): Comparison of the nurses' practice pre- and post-implementation of the bundle protocol training (n=50).

Nursing practices	No. of items	Pre (n=50) Mean±SD	Post (n=50) Mean±SD	t-Test	P-Value
Hand hygiene	12	9.82±0.62	18.34±4.30	13.86	<0.001
Wearing protective clothes	12	9.78±0.64	17.24±5.12	10.21	<0.001
Care of mechanical ventilator and settings	30	41.18±3.62	50.9±7.02	9.13	<0.001
Endotracheal tube care, suctioning techniques, and extubation	70	80.28±12.18	119.66±23.86	10.39	<0.001
Enteral feeding, removal, and care	38	16.3±2.13	21.88±6.00	6.19	<0.001
Oral hygiene	13	46.82±3.85	64.46±9.25	12.43	<0.001
Patients' positioning	10	18.16±5.49	20.36±1.79	2.69	<0.001
Chest physiotherapy	50	11.14±2.07	13.94±3.84	4.11	<0.001
Closed suctioning system	15	65.08±7.42	85.7±12.33	10.13	<0.001
Total practice	250	300.76±32.68	410.28±73.79	9.59	<0.001

Table (5): Comparison of nurses' total practice levels before and after bundle implementation training (n=50).

Practice levels	Pre (n=50)		Post (n=50)		X^2	P- value
	N	%	N	%		
Poor	35	70	10	20		
Average	8	16	7	14	35.3743	<0.001
Good	7	14	33	66		

Table (6): Comparison of the nurses' compliance to bundle practices before and after VAP bundle protocol implementation (n=50).

VAP bundle practices	No. of items	Pre (n=50) Mean±SD	Post (n=50) Mean±SD	t-Test	P-value
Infection control practices	5	6.1±1.34	8.58±1.74	7.96	<0.001
Positioning strategies	1	0.8±0.4	1.46±0.49	7.30	<0.001
Deep venous thrombosis prophylaxis	1	0.84±0.36	1.44±0.49	6.88	<0.001
Ventilator care	5	4.88±1.59	7.66±1.76	8.27	<0.001
Endotracheal Suctioning care	10	9.74±2.97	15.82±4.89	7.50	<0.001
Oral care protocol	2	2.82±0.38	3.7±0.45	10.45	<0.001
Peptic ulcer prophylaxis	3	3.5±0.64	4.58±0.75	7.74	<0.001
Extubation and weaning trials	2	2.58±0.49	3.66±0.51	10.72	<0.001
Total compliance	29	31.34±6.54	46.96±10.21	9.10	<0.001

Table (7): Comparison of total nurses' compliance before and after implementing the bundle protocol (N= 50).

Nurses' compliance levels	Pre-implementation n=50		Post-implementation n=50		X^2	P - value
	No.	%	No.	%		
Non-compliant	32	64	10	20		
partially compliant	15	30	11	22	66.52	<0.000
Good compliant	3	6	29	58		

Table (8): Correlation between total knowledge, practice, and compliance score of the studied nurses related to designed bundle protocol (n=50).

Variables	Total knowledge score				Total practice score			
	Pre implementation		Post implementation		Pre implementation		Post implementation	
	r	p	r	P	r	p	r	P
Total compliance score	0.68	>0.05	0.89	<0.001	0.62	>0.05	0.94	<0.001

Table (9): Comparison of control and study group patients' demographic and medical characteristics (N=66).

Sociodemographic	Control group (n=33)		Study group (n=33)		X^2	P - value
	No	%	No	%		
Age (years)						
<40	8	24.2	9	27.3	0.07	>0.05
>40	25	75.8	24	72.7		
Mean±SD	52.66±9.67		51.96±9.95			
Gender						
Male	16	48.5	15	45.5	0.06	>0.05
Female	17	51.5	18	54.5		
Marital status						
Married	29	87.9	30	90.9	0.68	>0.05
Unmarried	4	12.1	3	9.1		
Working						
Work	21	63.6	19	57.6	0.25	>0.05
Not work	12	36.4	14	42.4		
Residence						
Rural	22	66.7	20	60.6	0.60	>0.05
Urban	11	33.3	13	39.4		
Diagnosis						
Cerebrovascular stroke	10	30.3	12	36.4		
Pulmonary disease	5	15.15	2	6		
Hepatic encephalopathy & Liver failure	5	15.15	3	9		
Myocardial infarction	6	18.2	5	15.15	0.64	>0.05
Diabetes Mellitus	15	45.45	10	30.3		
Cerebral hemorrhage	7	21.2	6	18.2		
Renal failure	3	9	2	6		
Heart failure	2	6	1	3		
Smoking history						
Yes	8	24.25	6	18.2	0.36	>0.05
No	25	75.75	27	81.8		
Causative organism						
Staphylococcus aureus	18	54.5	20	60.6		
Klebsiella pneumonia	6	18.2	7	21.2	0.67	>0.05
Pseudomonas aeruginosa	9	27.3	6	18.2		

Table (10): Comparison of study and control group patients' outcome of clinical pulmonary infection pre- and post-implementation of bundle protocol (n=66).

Variable	Before implementation Control (n=33)		After implementation Study (n=33)		X^2	P - value
	N	%	N	%		
Temperature						
36.5-37.5	6	18.2	16	48.5		
37.5-38.9	13	39.4	13	39.4	7.4714	<0.05
>39	14	42.4	4	12.1		
Mean±SD	1.24± 0.739		0.515±0.499			
White blood cells (WBCs)						
4.0-11.0	4	12.1	15	45.4		
11.0-17.0	17	51.5	12	36.4	7.2	<0.05
>17.0	12	36.4	6	18.2		
Mean±SD	1.18±0.625		0.878±0.477			
Secretion						
None	4	12.1	16	48.4		
Mild/non-purulent	13	39.4	12	36.4	8.2549	<0.05
Purulent	16	48.5	5	15.2		
Oxygenation status						
>100 mmHg	9	27.2	14	42.4		
75-<80 mmHg	12	36.4	13	39.4	2.1773	>0.05
<75 mmHg	12	36.4	6	18.2		
Mean±SD	1.272±0.663		1±0.246			
Radiographic findings						
No infiltrate	7	21.2	17	51.5		
Diffuse	17	51.5	12	36.4	4.3663	>0.05
Infiltrate	9	27.3	4	12.1		
Culture of pathogenic bacteria						
No or mild growth	13	39.4	20	60.6	7.7912	<0.05
Moderate florid growth	10	30.3	7	21.2		
Pathogen consistent	10	30.3	6	18.2		

Table (11): Comparison of total mean score of CPIS before and after implementation of the bundle protocol

Total score	Before implementation Control group	After implementation study group	t- Test	P-Value
Min-Max	4.0-10.0	0.0-7.0		
Mean±SD	7.08 ± 1.56	3.51 ± 1.53	9.38	<0.001

Table (12): Mean and standard deviation of the studied patients according to the length of stay and duration on the mechanical ventilator.

Variables	Before intervention Control (n=33) Mean±SD	After intervention Study (n=33) Mean±SD	t-Test	P-Value
Length of stay in intensive care unit	15.030 ± 0.797	9.787 ± 0.844	20.70	<0.001
Duration of mechanical ventilator	12.727 ± 1.023	7.606 ±1.099	20.05	<0.001

6. Discussion

Ventilator-associated pneumonia (VAP) is a common nosocomial infection in critically ill patients that is associated with poor clinical outcomes and economic burden, including longer duration of intubation, longer ICU and hospital stay, high rate of mortality, and increased hospital charges *(Ghimire & Neupane, 2018)*. So, the present study aimed to evaluate the effect of the designed bundle protocol about ventilator-associated pneumonia on nurses' performance, compliance, and patient outcomes.

The current study findings reported that nearly three-quarters of nurses were less than 30 years old, with a mean age of 30.82±8.88. Most of them were married, and more than half had between 5-10 years of experience. This finding might indicate that the more critical care nurses experience, the more liable to increase capacities related to cognition, clinical judgment, and decision-making concerning the care of critically ill patients. Supporting this study's findings, *Alkhazali (2017)*, in his study entitled "Critical care nurses' knowledge on prevention of ventilator-associated pneumonia and barriers of compliance to preventive measures" at Near East University, Institute of Health Sciences, reported that the mean ages of the studied group were 30 years old, their experiences within critical care unit started from 5 years, and most of the studied group were married.

This result disagrees with *Bankanie et al. (2021)*, who conducted a cross-sectional study to identify ICU nurses' knowledge and compliance with evidence-based guidelines to prevent VAP and noticed that nurses' age was between 31 and 39 years.

Regarding the level of education for nurses, the present study's finding indicates that the highest percentage of nurses had a secondary school diploma in nursing and more than three-quarter of nurses' job was as a staff nurse. This finding might be due to the new nurses with secondary school diploma in nursing education were distributed in critical care units rather than other units in the hospital to match the patient care demands. Supporting this study's findings, *Hassan et al. (2021)*, who studied "Assessment of knowledge and practice of ICU nurses regarding prevention of ventilator-associated pneumonia (VAP) at a tertiary care hospital," reported that nearly half of nurses carry a diploma in nursing. This result disagrees with *ALaswad and Bayoumi (2022)*, who studied " Improvement of the nurses' awareness toward ventilator-associated pneumonia based on evidence guidelines" and reported that the bachelor's degree holders were a large proportion.

The current study findings illustrate that most studied nurses do not receive any previous training in ventilator-associated pneumonia prevention bundle. This result might be due to a lack of hospital financial resources, shortage of nursing staff, and work overload, which is considered a barrier for nurses to leave work and attend any training course, and this might be the reason behind their unsatisfactory knowledge practices before bundle protocol training. In agreement with this finding, *Khalifa and Seif Eldin (2020)*, whose study about " The impact of an educational training program on nurses in reduction of ventilator-associated pneumonia," reported that nearly all the studied nurses were not participating in the training sessions.

Disagreement with this study finding *by Alkhazali et al. (2021)*, who studied " Knowledge and barriers of critical care nurses regarding evidence-based practices in ventilator-associated pneumonia prevention using descriptive cross-sectional design in two hospitals in Jordan" and found that most nurses gained their knowledge not directly from nursing schools but from the in-service training program.

Regarding nurses' knowledge, the current study reveals that nurses' total knowledge level demonstrates that three-quarters of studied nurses had poor total knowledge scores pre-designed bundle implementation. This finding might be due to one or more of the following reasons: lack of orientation program prior to work as well lack care conferences during work, non-availability of procedure book specially prepared for the critical care areas, and lack of direction and nurse's appraisal about ventilator patient's care in specific areas like percussion, vibration, postural drainage, and ventilator system settings and connections.

Congruence with this study finding by *Bhandari et al. (2021)* studied "Knowledge of nurses working in critical care areas regarding ventilator-associated pneumonia prevention bundles in a tertiary level cardiac center" and found that only a few percent of nurses had correct knowledge about ventilator-associated pneumonia. *Osti et al. (2017)* also studied " Ventilator-associated pneumonia and role of nurses in its prevention." They demonstrated that the occurrence of ventilator-associated pneumonia is directly related to insufficient knowledge and understanding of the pathophysiology and risk factor regarding the development and prevention strategies of ventilator-associated pneumonia. In contradiction with the study finding, *Hassan et al. (2021)* mentioned that most ICU nurses had moderate knowledge about ventilator-associated pneumonia preventive measures.

In comparison, the current study findings reported that nearly two-thirds of them had a good knowledge immediately after post-designed bundle protocol training, with a statistically significant difference between the nurses' knowledge in the pre- and post-study phases (in all knowledge elements and the total). This might be due to the implementation of the educational session, supported by a printed guideline booklet. Besides, the practical training allows the nurses to demonstrate and redemonstrate the bundle procedures. These findings support the first research hypothesis.

In agreement with this study's findings, *ALaswad and Bayoumi (2022)* indicated an improvement in general knowledge after ventilator-associated pneumonia evidence-based guidelines implementation. Also, this finding agrees with Rakhi *and Navita (2020)*, who concluded that more than three-quarters of their participants had a poor level of total knowledge pre- intervention, which improved to a good level at immediate post-test. *Khalifa and Seif Eldin (2020)* also documented that the nurses' general knowledge level improved post-educational program and the result was statistically significant.

Regarding nurses' practice, the current study findings demonstrate a statistically significant improvement in the total practice mean score and all the practice elements immediately post-bundle implementation as compared by pre bundle implementation training. The current study reveals that the majority had a poor practice pre-VAP bundle implementation; this might be due to most nurses having poor knowledge pre-bundle implementation and there is lack of in-service training programs. However, post-VAP bundle implementation, near two third of nurses had a good level of practice, with a statistically significant difference between the two study phases. These findings support the second research hypothesis.

In the same line, *Sharma and Mudgal (2018)*, whose study about "Knowledge and skill regarding the care of a patient on mechanical ventilator among the staff nurses working in a selected hospital," stated that pre-test skill scores were lower than the post-test skill score and there was a significant difference between the pre-test and post-test practice scores. This finding agrees with *Abad et al. (2021)*, whose study on "Assessment of knowledge and implementation practices of the ventilator acquired pneumonia (VAP) bundle in the intensive care unit of a private hospital" and reported that the lack of education and practices were consistently identified as the principal reasons precluding proper implementation of the VAP bundle. This finding was consistent with *Hassan et al. (2021)*, who reported that most staff nurses had unsatisfactory practice and needed prevention of VAP guidelines to promote nurses' performance.

As well, *Getahun et al. (2022)*, whose study about "Knowledge of intensive care nurses' towards prevention of ventilator-associated pneumonia in Northwest Ethiopia referral hospitals," revealed that ICU nurses who had taken training on VAP prevention were higher skillful than nurses who had not taken regular training. Findings were consistent with a study conducted by *Uma and Amoldeep (2022)*, whose study about "Effectiveness of nursing care bundle in terms of knowledge and practices regarding the care of patients on mechanical ventilator among nursing personnel," reported a statistically significant difference in the post-test practices score among experimental group than pre-test practices score of the control group.

Contradiction to these study findings, *Busi and Ramanjamma (2016)*, whose study about "The effectiveness of structured teaching program on the level of knowledge and practice regarding prevention of VAP among critical care nurses of General Hospital, Guntur, Andhra," revealed that majority of the staff nurses had moderate knowledge and practice before implementing structured teaching program.

Regarding compliance to a designed bundle protocol, findings of the present study reveal that near two third of the studied nurses were non-compliant to bundle procedures before bundle training. This finding might be due to lack of knowledge, workload, and lack of strict monitoring protocols for compliance with ventilator-associated pneumonia bundle. In comparison, more than half of them had a good compliance level after the intervention, with a highly statistically significant difference between pre- and post-intervention compliance for all procedures and the total. This might be due to the improvement in the nurses' knowledge and practice after bundle application. These findings support the third research hypothesis.

Supporting this study's findings, *Neef et al. (2019)* illustrated that many critical care nurses did not comply with most VAP bundle practices before intervention and improved after designed bundle protocol implementation. In the same line, *Aloush (2018)* conducted a study on "Nurses' implementation of ventilator-associated pneumonia prevention guidelines: An observational study in Jordan" and showed that nurses' compliance was unsatisfactory before implementing ventilator-associated pneumonia prevention guidelines. *Al-Sayaghi (2021)*, in a study entitled " Critical care nurses' compliance and barriers toward ventilator-associated pneumonia prevention guidelines: Cross-sectional survey," showed that nurses who had prior education regarding VAP prevention had a significantly higher compliance score than the no education group.

In contradiction to this study's findings, *Bankanie et al. (2021)*, whose study about " Assessment of knowledge and compliance to evidence-based guidelines for VAP prevention among ICU nurses in Tanzania," documented that the mean self-reported of compliance to evidence-based guidelines for the prevention of ventilator-associated pneumonia was high.

The correlation between nurses' performance and compliance toward the designed care bundle protocol for preventing VAP showed positive correlations between nurses' performance (knowledge and practice) and their compliance after implementing the bundle protocol. This finding might be because compliance is enhanced with good knowledge and practice and vice versa. Supporting these findings, *Bird et al. (2020)* conducted a study on adherence to ventilator-associated pneumonia bundle and incidence of ventilator-associated pneumonia in the surgical intensive care unit. They found that the staff nurses' compliance with the VAP bundle increased over the study period after its implementation, with a statistically significant correlation between nurses' compliance and performance.

Regarding patients' demographic characteristics, patients' age reveals that three-quarters of the study and control group aged more than 40 years old, most study and control patients were married and from rural areas. This finding might be due to co-morbidity increasing with age and increasing the risk of ICU admission, In addition to the study setting serve many rural area around Benha University Hospitals. This result is consistent with *Ali et al. (2020)*, whose study about" Assessment the incidence of ventilator-associated pneumonia for critically ill patients in the intensive care unit," found that nearly three-quarters of studied patients had aged more than forty years old.

Regarding medical history, highest percentage of the study and control group had a medical history of cerebrovascular stroke, diabetes, and cerebral hemorrhage. This finding could be due to the nature of ICU admission as it was an emergency ICU that received many patients traumatized by a road traffic accident. Most patients were also admitted because of disturbed conscious levels, a complication of chronic diseases like diabetes mellitus.

These results agree with *Othman et al. (2017)* in their study entitled " Ventilator-associated pneumonia, incidence and risk factors in emergency intensive care unit Zagazig university hospitals" showed that stroke and cerebral hemorrhage were the most common diagnosis of ICU admission. In the same line *Kudiyarasu (2016)*, who conducted a study to assess the effectiveness of ventilator bundle on the prevention of ventilator-associated pneumonia among patients on a mechanical ventilator at selected hospitals, Erode, found that about half of both experimental and control groups, the central nervous system diseases were the main reasons for ICU admission and result in a mechanical ventilator connection.

The present study found that the causative organism in both the study and control group is Staphylococcus aureus. This finding could be due to Staphylococcus aureus being the leading cause of infection in critical care units. This pathogen causes life-threatening infections in intensive care units. Also, due to aspiration of secretions or the use of contaminated equipment, organisms may spread through the oropharynx, sinus cavities, nares, dental plaque, gastrointestinal tract, patient-to-patient contact, and ventilator circuit leading to bacterial colonization of the lungs. So, it is recommended to follow certain strategies such as proper hand washing, oral decontamination, stress ulcer prophylaxis, avoiding saline lavage with suctioning, turning patients at least every 2 hours, and changing the ventilator circuit when it is contaminated. Supporting this study's results, *El-Saed et al. (2016)* found that staphylococcus aureus was the most frequently isolated causative agent for ventilator-associated pneumonia. In contradiction to this study's findings, *Othman et al. (2017)* reported that Klebsiella pneumonia was isolated from less than half of patients with VAP.

The current study findings illustrate non-statistically significant differences were seen between the two studied groups concerning the demographic and medical variables, which indicates that the two groups were nearly homogenous.

The current study findings illustrated that there is a statistically significant difference between all items of clinical pulmonary infection score (CPIS) of the study (patient admitted after bundle application) and control group (patients admitted before bundle application). This finding might be due to implementing the VAP bundle protocol with trained, compliant nurses. These findings support the fourth research hypothesis.

Montasser (2017) supports this finding in his study entitled "Decreasing the incidence of ventilator-associated pneumonia with complete adherence to its prevention bundle" at Al–Hayat Hospital, Jeddah, KSA. The study illustrated that the application of ventilator-associated pneumonia (VAP) prevention bundle reduces the frequency of ventilator-associated pneumonia. These results indicated a positive impact on patient outcomes with strict application of the VAP bundle.

In the same line, *Neef et al. (2019)* stated that the primary outcome of this study was the difference in the incidence rate of VAPs before and after the implementation of the prevention bundle. In the same line *as Mogyoródi et al. (2016),* the study entitled "Ventilator-associated pneumonia and the importance of education of ICU nurses on prevention: Preliminary results" showed a reduction in the incidence and risk of VAP after the implementation of the bundle.

The current study found a substantial statistically significant decrease in the CPIS means score VAP after implementing the ventilator care bundle. This finding might be due to implementing the VAP bundle protocol with trained, compliant nurses. In agreement with this study finding, *Beatriz (2017),* in a study entitled "Nursing actions to prevent mechanical ventilation pneumonia in the intensive care unit," found that, before implementation of the ventilator bundle, the VAP rate was high; and after implementation of ventilator bundle VAP rate decreased with a statistically significant difference.

Related to the length of stay within the intensive care unit and duration of patients on a mechanical ventilator, the current study findings demonstrate statistically significant differences between the study and control group regarding their length of stay within the intensive care unit and duration of the patient on a mechanical ventilator. These findings support the fourth research hypothesis.

This finding is consistent with *Shi et al. (2022)* in a study entitled "Analysis of the nursing effect of critical respiratory illness based on refined nursing management," which found that post application of nursing management, a reduction in secondary infection, thereby reducing the incidence of VAP in patients on mechanical ventilation, shortening the time of mechanical ventilation and ICU stay time. This finding agrees with Radhakrishnan *et al. (2021),* whose study about "Effect of training and checklist-based use of ventilator-associated pneumonia (VAP) prevention bundle protocol on the patient outcome: A tertiary care center study," stated that the implementation of the bundle components, would translate into better outcomes in terms of lower incidence of VAP, hospital mortality and hospital length of stay in patients on mechanical ventilation.

7. Conclusion

Based on the current study results and research hypotheses, the following can be concluded:

The study group nurses who received the designed bundle protocol got higher knowledge, practices, and compliance scores than pre-designed bundle protocol implementation. Also, the study group patients who were cared for by a designed bundle protocol exhibited better outcomes such as a significantly lower score of CPIS, shorter length of stay in the intensive care unit, and less duration on mechanical ventilation compared to the control group who received routine hospital nursing care.

8. Recommendations

Based on the results of the present study, the following can be recommended:

- Continued nursing education and in-service training programs should be well organized and periodically implemented to improve nurses' performance and compliance with VAP prevention.
- Continuous evaluation of nurses' knowledge, practice, and compliance with VAP is essential to identify their training needs in intensive care units regarding hospital-acquired infection and infection control measures.
- Hospital policies should include updated evidence-based guidelines for VAP prevention bundles and protocols from international evidence.
- Further study is required to apply the VAP bundle strategy with a larger sample size and estimate its effect on nurses' performance in caring for critically ill patients under mechanical ventilation and patient outcomes.

9. References

Ab Manap N. (2019). Critical care nurses' knowledge in prevention of ventilator-associated pneumonia. ILKKM *Journal of Medical and Health Sciences, 1*(1), 25-30.

Abad, C. L., Formalejo, C. P., & Mantaring, D. L. (2021). Assessment of knowledge and implementation practices of the ventilator acquired pneumonia (VAP) bundle in the intensive care unit of a private hospital, *Antimicrobial*

Resistance & Infection Control, *10*(1), 161. https://doi.org/10.1186/s13756-021-01027-1.

Abdelazeem, E., Fashafsheh, I., & Fadllalah, H. (2019). Effect of training program on nurses' knowledge and competence regarding endotracheal tube and tracheostomy care in mechanically ventilated patients. *International Journal of Nursing*, *6*(1), 1-6. https://doi.org/10.15640/ijn.v6n1a6.

Ahmed, R. Q., Sobeih, H. S., & Abdelsalam, S. N. (2019). Ventilator-associated pneumonia bundle among mechanically ventilated patient: Nurses' perception. *Egyptian Journal of Health Care*, *9*(2), 264-277 https://doi.org/10.21608/ejhc.2018.20246.

Alaswad, Z. M., & Bayoumi, M. (2022). Improvement of the nurses' awareness toward ventilator-associated pneumonia based on evidence guidelines, *Springer journal*, *13*(2), 95-100. https://doi.org/10.4103/injms.injms_124_21.

Ali, H. A., Abd El Mawla, T. S., & Ahmed, S. R. (2020). Assessment the incidence of ventilator-associated pneumonia for critically ill patients in the intensive care unit, *Egyptian Journal of Health Care*, *11*(4), 32-39.

Alkhazali, M. N., Bayraktar, N., & Al-Mugheed, K. A. (2021). Knowledge and barriers of critical care nurses regarding evidence-based practices in ventilator-associated pneumonia prevention, *Cyprus J Med Sci.*, *6*(3), 185-191, https://doi.org/10.5152/cjms.2021.1292.

Alkhazali, M. (2017). Critical care nurses' knowledge on prevention of ventilator-associated pneumonia and barriers of adherence to preventive measures. Master of Nursing, Near East University, Institute of Health Sciences.

Aloush, S. M. (2018). Nurses' implementation of ventilator-associated pneumonia prevention guidelines: An observational study in Jordan. *Nursing in Critical care*, *23*(3), 147-151. https://doi.org/10.1111/nicc.12323.

Al-Sayaghi, K. M. (2021). Critical care nurses' compliance and barriers toward ventilator-associated pneumonia prevention guidelines: Cross-sectional survey. *Journal of Taibah University Medical Sciences*, *16*(2), 274e282, https://doi.org/10.1016/j.jtumed.2020.12.001.

Bakhtiari, S., Yazdannik, A., Abbasi, S., & Bahrami, N. (2018). The effect of an upper respiratory care program on incidence of ventilator-associated pneumonia in mechanically ventilated patients hospitalized in intensive care units. *Iranian Journal of Nursing Research*, *20*(3). Available at: http://www.ijnmrjournal.net. Accessed on 12/1/2020 at 11 Am.

Bankanie, V., Outwater, A., Wan, L., & Yinglan, L. (2021). Assessment of knowledge and compliance to evidence-based guidelines for vap prevention among icu nurses in Tanzania, BMC Nurs., 20(1), 209. https://doi.org/10.21203/rs.3.rs-117804/v1.

Beatriz, A. B. (2017). Nursing actions to prevent mechanical ventilation pneumonia in the intensive care unit: Review. *Rev Lat Am Enfermagem*, *6*, 59-64.

Benha University Office Census, (2019). Number of patients undergoing mechanical ventilation and exposed to ventilated associated pneumonia in the intensive care unit, Benha University Hospital, Elkalyoubeya, Egypt.

Bhandari, S., Sharma, M., & Shrestha, G. S. (2021). Knowledge of nurses working in critical care areas regarding ventilator-associated pneumonia prevention bundles in a tertiary level cardiac center. *J Inst Med Nepal*, *43*(1), 36-42. https://doi.org/10.3126/jiom.v43i1.37470.

Bird, D., Zambuto, N. P., O'Donnell, C., Silva, J., Korn, C., Burke, R., Burke, P., & Agarwal, S. (2020). Adherence to ventilator-associated pneumonia bundle and incidence of ventilator-associated pneumonia in the surgical intensive care unit. *Arch Surg.*, *145*(5), 465-70. https://doi.org/10.1001/archsurg.2010.69.

Boltery, E., Yakusheva, O., & Costa, D. K. (2017). Nursing strategies to prevent ventilator-associated pneumonia, *Am Nurse Today*. *12*(6), 42-43, https://pubmed.ncbi.nlm.nih.gov/29201265/.

Busi, S., & Ramanjamma, K. (2016). Effectiveness of structured teaching program on level of knowledge and practices regarding prevention of ventilator-associated pneumonia among critical care nurses of NRI General Hospital, Guntur, A.P., India. *Int J Adv Nur Mgmt.*, *4*(2), 125-9. https://doi.org/10.5958/2454-2652.2016.00028.7.

Centers for Disease Control and Prevention (CDC). (2021). Pneumonia (Ventilator-associated [VAP] and non-ventilator-associated Pneumonia [PNEU]) Event. 2021. https://www.cdc.gov/nhsn/pdfs/ pscmanual/6pscvapcurrent .

El-Saed, A., Al-Jardani, A., Althaqafi, A., Alansari, H., Alsalman, J., Al Maskari, Z., El Gammal, A., Al Nasser, W., Al-Abri, S., & Balkhy, H. (2016). Ventilator-associated pneumonia rates in critical care units in 3 Arabian Gulf countries: A 6-year surveillance study. *Am J Infect Control*, *44*(7), 794-8. https://doi.org/10.1016/j.ajic.2016.01.042.

European Society of Intensive Care Medicine (2017). New guidelines for hospital-acquired pneumonia/ventilator-associated pneumonia: USA vs. Europe, *Eur Respir J.*, *50*(3), 1700582. https://doi.org/10.1183/13993003.00582-2017.

Getahun, A. B., Belsti, Y., Getnet, M., Bitew, D. A., Gela, Y. Y., Belay D. G., Terefe, B., Akalu, Y., & Diress, M. (2022). Knowledge of intensive care nurses towards prevention of ventilator-associated pneumonia in Northwest Ethiopia referral hospitals, 2021: A multicenter, cross-sectional study, *Annals of Medicine and Surgery*, *78* (2022) 103895. https://doi.org/10.1016/j.amsu.2022.103895.

Ghimire, S., & Neupane, S. (2018). Knowledge regarding prevention of ventilator-associated pneumonia among nurses in a tertiary hospital, Rupandehi, Nepal. *Journal of Universal College of Medical Sciences*, *6*(1), 27-31. https://doi.org/10.3126/jucms.v6i1.21721.

Hassan, S., Wani, D., Annu, S., Iqbal, U., Bharti, K., & Nabi, R. (2021). Assessment of knowledge and practice of ICU nurses regarding prevention of ventilator-associated pneumonia (VAP) at a tertiary care hospital, Jammu and Kashmir, *Indian Journal of Holistic Nursing*, *12*(3), 1-8 https://medicaljournalshouse.com/index.php/IndianJournal-HolisticNursing/article/view/610.

Institute for Healthcare Improvement. (2020). Bundle up for safety. https://www.ihi.org/resources/Pages/ImprovementStories/BundleUpforSafety.aspx.

Kalil, A. C., Metersky, M. L., & Klompas, M., Muscedere, J., Sweeney, D., Palmer, L., Napolitano, L., O'Grady, N., Bartlett, J., Carratalà, J., El Solh, A., Ewig, S., Fey, P., File Jr. T., Restrepo, M., Roberts, J., Waterer, G., Cruse, P., Knight, S., & Brozek, J. (2016). Management of adults with hospital-acquired and ventilator-associated pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of America and the American Thoracic Society. *Clin Infect Dis.*, *63*(5), e61–e111. https://doi.org/10.1093/cid/ciw353.

Kao, C., Chiang, H., Chen, C., Hung, C., Chen, Y., Su, L., Shi, Z-Y., Liu, J-W., Liu, C-P., Chuang, Y-C., Ko., W.C., Chen, Y-H., Tseng, S. H., Lee, C-M., Lu, M. C., Hsueh, P. R., & Infection Control Society of Taiwan (2019). National bundle care program implementation to reduce ventilator-associated pneumonia in intensive care units in Taiwan. Journal Of Microbiology, *Immunology, and Infection, 52*(4), 592-597. https://doi.org/10.1016/j.jmii.2017.11.001.

Khalifa, E. M., & Seif Eldin, A. S. (2020). The impact of an educational training program on nurses in reduction of Ventilator-associated pneumonia. *Egypt J Occup Med.*, *44*(3), 709-26. https://doi.org/10.21608/EJOM.2020.118350.

Khalil, N. S., Mohamed, H. A., & Sayed, O. A. (2021). Impact of educational program regarding ventilator-associated pneumonia bundle on critical care nurses' knowledge and practices, *Mansoura Nursing Journal*, *8*(Special Issue-2021), 301-318. https://mnj.journals.ekb.eg/article_213213_da949a4a886754fa09642ab7f3ce432a.pdf.

Krishnappa, S., Rachaiah, J. M., Hegde, S., Sadananda, K. S., Nanjappa, M. C., Ramasanjeevaiah, G., & Kanakalakshmi, R. C. (2018). High-risk Parahisian pathways-mid septal and anteroseptal: Feasibility, advantages, safety, and outcomes of alternate site approach– A single center study. *Journal of Cardiovascular Disease Research*, *9*(2), 71-75. https://doi.org/10.5530/jcdr.2018.2.18.

Kudiyarasu, T. (2016). A study to assess the effectiveness of ventilator bundle on prevention of ventilator-associated pneumonia among patients on mechanical ventilator at selected hospitals, Erode. Master's thesis, Anbu College of Nursing, Komarapalayam. http://repositorytnmgrmu. ac.in/id/eprint/10077.

Klompas, M. (2017): Oropharyngeal decontamination with antiseptics to prevent ventilator-associated pneumonia: rethinking the benefits of Chlorhexidine. *Semin Respir Crit Care Med.*, *38*(3), 381–90. https://doi.org/10.1055/s-0037-1602584.

Leone, M., Bouadma, L., Bouhemad, B., Brissaud, O., Dauger, S., Gibot, S Hraiech, S., Jung, B., Kipnis, E., Launey, Y., Luyt, C. E., Margetis, D., Michel, F., Mokart, D., Montravers, P., Monsel, A., Nseir, S., Pugin, J., Roquilly, A., Velly, L., Zahar, J-R., Bruyere, R., & Chanques, G. (2018). Hospital-acquired pneumonia in ICU. *Anesthesia Critical Care & Pain Medicine, 37*(1), 83-98. https://doi.org/10.1016/j.accpm.2017.11.006

Mishra, R., & Rani, N. (2020). Effectiveness of structured teaching program on knowledge and practice regarding care bundle on prevention of ventilator-associated pneumonia among nurses. *Int Arch Nurs Health Care*, *6*, 149. https://doi.org/10.23937/2469-5823/1510149.

Mogyoródi, B., Dunai, E., Gál, J., & Iványi, Z. (2016). Ventilator-associated pneumonia and the importance of education of ICU nurses on prevention–Preliminary results. *Interventional Medicine and Applied Science*, *8*(4), 147-151**.** https://doi.org/10.1556/1646.8.2016.4.9.

Montasser, M. G. (2017). Decreasing the incidence of ventilator-associated pneumonia with complete adherence to Its prevention bundle, *Al-Azhar Med. J.*, *46*(2), 425-432. https://doi.org/10.12816/0038264.

Neef, M. D., Bakker, L., Dijkstra, S., Raymakers-Janssen, P., Vileito, A., & Ista, A. (2019). Effectiveness of a ventilator care bundle to prevent ventilator-associated pneumonia at the PICU: A systematic review and meta-analysis, *Pediatric Critical Care Medicine*, *20*(5), 474-480. https://doi.org/10.1097/PCC.0000000000001862.

Osti, C., Wosti, D., Pandely, B., & Zhao, Q. (2017). Ventilator-associated pneumonia and role of nurses in its prevention. *J Nepal Med Assoc.*, *56*(208), 461-8, https://doi.org/10.31729/jnma.3270.

Othman, H. A., Gamil, N. M., Elgazzar, A. M., & Fouad, T. A. (2017). Ventilator-associated pneumonia, incidence, and risk factors in emergency intensive care unit Zagazig university hospitals, *Egyptian Journal of Chest Diseases and Tuberculosis*, *66* (2017), 703–708. https://doi.org/10.1016/j.ejcdt.2017.08.004.

Radhakrishnan, R., Sood, R., Wig, N., Sethi, P., Soneja, M., Kumar, A., Nischal, N., Biswas, A., & Pandey, R. M. (2021). Effect of training and checklist-based use of ventilator-associated pneumonia (VAP) prevention bundle protocol on patient outcome: A tertiary care centre study, *Journal of The Association of Physicians of India*, *69*(8), 11-12. https://pubmed.ncbi.nlm.nih.gov/34472810/.

Rakhi, M., & Navita, R. (2020). Effectiveness of structured teaching program on knowledge and practice regarding care bundle on prevention of ventilator-associated pneumonia among nurses. *International Archives of Nursing and Health Care*, *6*(4), 1-3. https://doi.org/10.23937/2469-5823/1510149.

Reichardt, C. S. (2019). *Quasi-Experimentation. A Guide to Design and Analysis*, Guilford Press, *New York, London.* P. *47.* https://www.guilford.com/books/Quasi-Experimentation/Charles-Reichardt/9781462540204.

Rodrigues, A. N., Fragoso, L. V. C., Beserra, F.M., & Ramos, I. C. (2016). Determining impacts and factors in ventilator-associated pneumonia bundle. *Rev Bras Enferm.*, *69*(6), 1045-51. https://doi.org/10.1590/0034-7167-2016-0253.

Schauwvlieghe, A. F. A. D., Rijnders, B. J. A., Philips, N., Verwijs, R., Vanderbeke, L., Van Tienen, C., Lagrou, K., Verweij, P., Van de Veerdonk, F. L., Gommers, D., Spronk, P., Bergmans, D., Hoedemaekers, A., Andrinopoulou, E., Van den Berg, C., Juffermans, N., Hodiamont, C., Vonk, A., Depuydt, P., Boelens, J., Wauters, J. (2018). Invasive aspergillosis in patients admitted to the intensive care unit with severe influenza: a retrospective cohort study. *Lancet Respir Med.*, *6*(10), 782-792. https://doi.org/10.1016/S2213-2600(18)30274-1.

Sharma, R., & Mudgal, S. K. (2018). Knowledge and skill regarding care of a patient on mechanical ventilator among the staff nurses working in selected hospital. *International Journal of Practical Nursing, 6*(3), 1-5. https://doi.org/10.21088/ijpn.2347.7083.6318.2.

Torres, A., Niederman, M. S., Chastre, J., Ewig, S., Fernandez-Vandellos, P., Hanberger, H., Kollef, M., Bassi, G., Luna, C., Martin-Loeches, I., Paiva, J., Read, R., Rigau, D., Timsit, J., Welte, T., & Wunderink, R. (2017). Guidelines for the management of hospital-acquired pneumonia (HAP)/ventilator-associated pneumonia (VAP) of the European Respiratory Society (ERS). *Eur Respir J.*, *50*(3), 1700582. https://doi.org/10.1183/13993003.00582-2017.

Uma, A. D., & Amoldeep, S. (2022). Effectiveness of nursing care bundle in terms of knowledge and practices regarding care of patients on mechanical ventilator among nursing personnel, *International Journal of Nursing Education*, *14*(2), 1-3. https://doi.org/10.37506/ijone.v14i2.17990.

USAID Assist Project (2018). The USAID ASSIST Project's approach to improving health care in low- and middle-income countries, AUGUST 2018. US Technical Report. Published by the USAID ASSIST Project. Chevy Chase, MD: University Research Co., LLC (URC). https://www.usaidassist.org.

Zilberberg, M. D., & Shorr, A. F. (2010). Ventilator-associated pneumonia: The clinical pulmonary infection score as a surrogate for diagnostics and outcome. *Clinical infectious diseases, 51*(Supplement_1), S131-S135. https://doi.org/10.1086/653062.